AMU | Applied Meteorology Unit

Quarterly Report
Fourth Quarter FY-14
31 October 2014

Infusing Weather Technology Into Aerospace Operations

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Delta 4 carrying the GSSAP project satellites for Air Force Space Command on 28 July 2014

Launch Support

Ms. Shafer supported the Falcon 9 Orbcomm launch on 14 July.

Ms. Shafer supported the Delta 4 AFSPC 4 launch on 28 July.

Dr. Bauman supported the Atlas 5 GPS 2F-7 launch on 1 August .

Ms. Crawford supported the Falcon 9 AsiaSat 8 launch on 5 August.

Ms. Shafer supported the Falcon 9 AsiaSat 6 launch on 7 September.

Dr. Watson supported the Atlas 5 CLIO launch on 16 September.

Ms. Crawford supported the Falcon 9 CRS 4 launch on 21 September.

This Quarter's Highlights

The AMU team continued work on five tasks for their customers:

- Ms. Crawford completed the final report for the dual-Doppler wind field task.

- Dr. Bauman completed transitioning the 915-MHz and 50-MHz Doppler Radar Wind Profiler (DRWP) splicing algorithm developed at Marshall Space Flight Center (MSFC) into the AMU Upper Winds Tool.

- Dr. Watson completed work to assimilate data into model configurations for Wallops Flight Facility (WFF) and Kennedy Space Center/Cape Canaveral Air Force Station (KSC/CCAFS).

- Ms. Shafer began evaluating the a local high-resolution model she had set up previously for its ability to forecast weather elements that affect launches at KSC/CCAFS.

- Dr. Watson began a task to optimize the data-assimilated model she just developed to run in real time.

## ENSCO

Quarterly Task Summaries

This section contains summaries of the AMU activities for the fourth quarter of Fiscal Year 2014 (July—September 2014). The accomplishments on each task are described in more detail in the body of the report starting on the page number next to the task name.

## Configuration and Evaluation of a Dual-Doppler 3-D Wind Field System (Page 5)

Customers: NASA's Launch Services Program (LSP), Ground Systems Development and Operations (GSDO), and Space Launch System (SLS) programs; and the National Weather Service in Melbourne, Florida (NWS MLB).

Purpose: Current LSP and GSDO and future SLS operations will be halted when winds exceed defined thresholds or when lightning is a threat. A wind field display showing areas of high winds or convergence, especially over areas with no observations, would be useful to 45th Weather Squadron (45 WS) and NWS MLB forecasters in predicting the onset of vehicle-critical weather phenomena, and can be used to initialize a local numerical weather prediction model to improve forecasts of these phenomena. Having a three-dimensional (3-D) wind field over the KSC/CCAFS area using freely available software and data from the three local Doppler weather radars will aid in using ground processing and space launch resources more efficiently by stopping or starting work in a timely manner.

Accomplished: Completed writing a first draft of the final report, which underwent internal AMU review and was then sent out for external customer review. Began creating a presentation for the National Weather Association (NWA) 39th Annual Meeting in October.
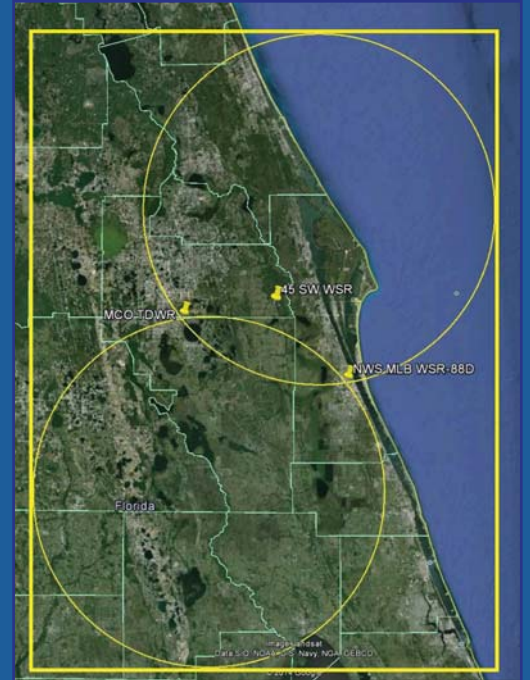
Transition MSFC Wind Profiler Splicing Algorithm to LSP Upper Winds Tool (Page 5)
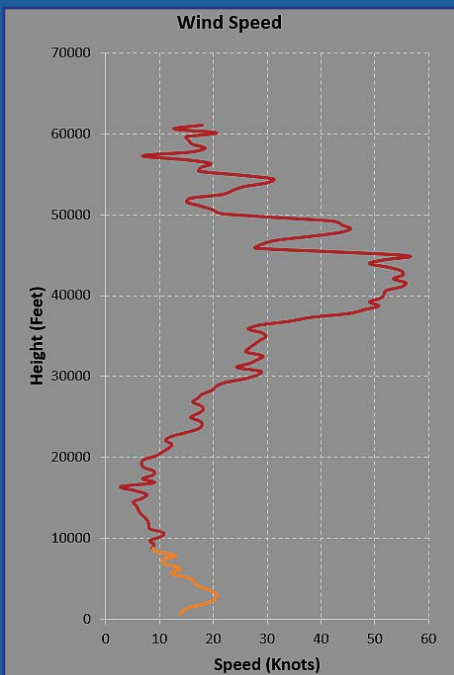
Customers: NASA's LSP and SLS program.

Purpose: NASA's LSP customers and the future SLS program rely on observations of upper-level winds for steering, loads, and trajectory calculations for the launch vehicle's flight. On the day of launch, the 45 WS Launch Weather Officers (LWOs) monitor the upper-level winds and provide forecasts to the launch team via the AMU-developed LSP Upper Winds tool. The goal of this task is to splice the wind speed and direction profiles from the 45th Space Wing (45 SW) 915-MHz DRWPs and KSC 50-MHz DRWP at altitudes where the wind profiles overlap to create a smooth profile. In the first version of the LSP Upper Winds tool, the top of the 915-MHz DRWP wind profile and the bottom of the 50-MHz DRWP were not spliced, creating a discontinuity in the profile. The MSFC Natural Environments Branch (NE) created algorithms to splice the wind profiles from the two sensors to generate an archive of vertically complete wind profiles for the SLS program. The AMU worked with MSFC NE personnel to implement these algorithms in the LSP Upper Winds tool to provide a continuous spliced wind profile.

Accomplished: Transitioned the Visual Basic for Applications (VBA) code into the LSP Upper Winds tool and tested it. Completed the final report, which is now on the AMU website.

Quarterly Task Summaries
(continued)

## Range-Specific High-Resolution Mesoscale Model Setup: Data Assimilation (Page 7)

Customers: NASA's LSP, GSDO, and SLS programs.

Purpose: Establish a high-resolution model with data assimilation for the Eastern Range (ER) and WFF to better forecast a variety of unique weather phenomena that affect NASA's LSP, GSDO, and future SLS programs daily and launch operations. Global and national scale models cannot properly resolve important local-scale weather features due to their coarse horizontal resolutions. A properly tuned model at a high resolution would provide that capability and provide forecasters with more accurate depictions of the future state of the atmosphere.

Accomplished: Finished validating Weather Research and Forecasting (WRF) model forecasts against local observation data using the Model Evaluation Tools (MET) verification package. Completed writing the final report in which model configuration recommendations are made for both the ER and WFF.
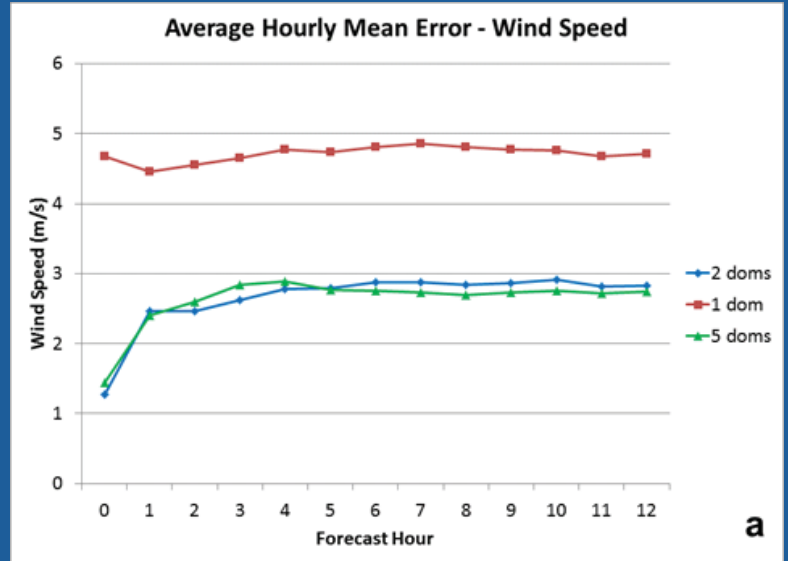
## Real-Time KSC/CCAFS High Resolution Model Implementation and Verification (Page 8)
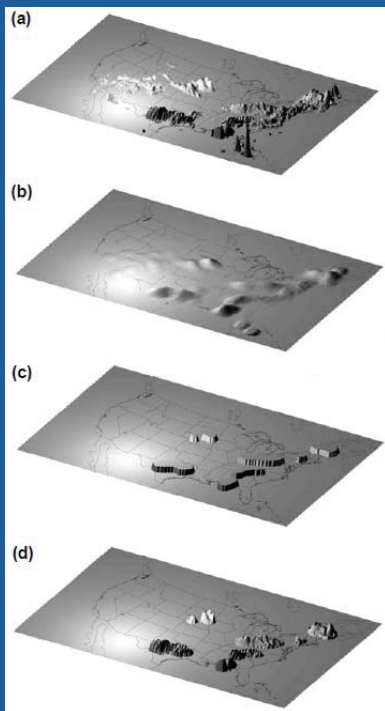
Customers: NASA's LSP, GSDO, and SLS programs.

Purpose: Implement a real-time version of the AMU high-resolution WRF Environmental Modeling System (WRF-EMS) model developed in a previous AMU task and determine its ability to forecast the unique weather phenomena that affect NASA's LSP, GSDO, and SLS daily and launch operations on KSC and CCAFS. Implementing a real-time version of WRF-EMS will create a larger database of model output than in the previous task for determining model performance compared to observational data. The AMU will also make the model output available on the AMU and 45 WS Advanced Weather Interactive Processing System (AWIPS) for real-time subjective analysis.

Accomplished: Determined preliminary model verification statistics for May and June 2014 using the MET software. Continued to generate statistics for the entire warm season (May–September 2014).
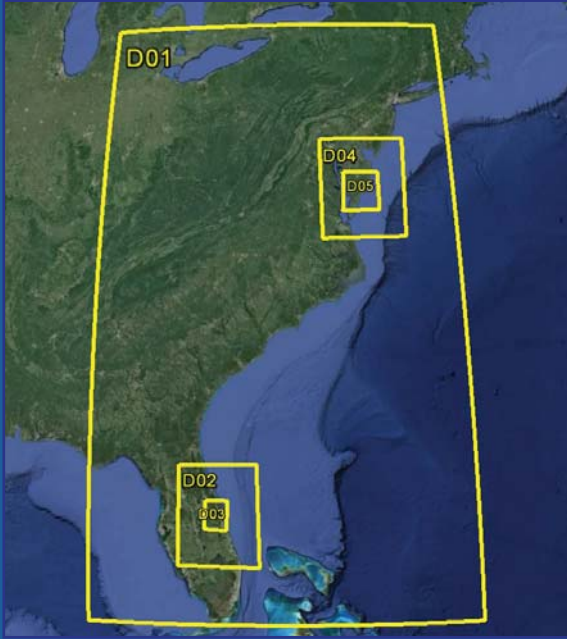
Range-Specific High-Resolution Mesoscale Model Setup—Optimization (Page 11)

Customers: NASA's LSP, GSDO, and SLS programs.

Purpose: Tune the numerical forecast model design for optimal operational performance for the ER and WFF to better forecast a variety of unique weather phenomena that affect NASA's SLS, LSP, and GSDO daily and launch operations. Global and national scale models cannot properly resolve important local-scale weather features due to their coarse horizontal resolutions. A properly tuned model at a high resolution would provide that capability and provide forecasters with more accurate depictions of the future state of the atmosphere.

Accomplished: Began preparing the Gridpoint Statistical Interpolation (GSI)/WRF scripts to run in real time.

AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

The progress being made in each task is provided in this section, organized by topic, with the primary AMU point of contact given at the end of the task discussion.

INSTRUMENTATION AND MEASUREMENT

Configuration and Evaluation of a Dual-Doppler 3-D Wind Field System (Ms. Crawford)

Current LSP, GSDO, and future SLS space vehicle operations will be halted when wind speeds from specific directions exceed defined thresholds and when lightning is a threat. Strong winds and lightning are difficult parameters for the 45 WS to forecast, yet are important in the protection of customer vehicle operations and the personnel that conduct them. A display of the low-level horizontal wind field to reveal areas of high winds or convergence would be a valuable tool for forecasters in assessing the timing of high winds, or convection initiation (CI) and subsequent lightning occurrence. This is especially important for areas where no other weather observation plat-

forms exist, such as inland west of the KSC/CCAFS area or east over the Atlantic Ocean. Developing a dual-Doppler capability would provide such a display to assist the 45 WS and NWS MLB forecasters in predicting high winds and CI. The wind fields can also be used to initialize a local mesoscale numerical weather prediction model to help improve the model forecast winds, CI, and other phenomena. Finally, data combined from two or more radars will lessen radar geometry problems such as the cone of silence and beam blockage. This display will aid in using ground processing and space launch resources more efficiently by stopping or starting work in a timelier manner. The AMU was tasked by the 45 WS and NWS MLB to develop a dual-Doppler display using data from three local Doppler radars and freely available software to derive the wind field over east-central Florida and over the

KSC/CCAFS area to support the safety of ground and launch operations. The radars include the 45 SW Weather Surveillance Radar (WSR), NWS MLB WSR 1988-Doppler (, and the Federal Aviation Administration (FAA) Terminal Doppler Weather Radar at Orlando International Airport.

Status

Ms. Crawford finished writing a first draft of the final report and submitted it for internal AMU review. After that review was completed, she sent the revised report to NWS MLB for customer review. Ms. Crawford also began creating a file for her oral presentation at the NWA 39th Annual Meeting in Salt Lake City, Utah, 19–23 October.

For more information contact Ms. Crawford at 321-853-8130 or crawford.winnie@ensco.com.

Transition MSFC Wind Profiler Splicing Algorithm to LSP Upper Winds Tool (Dr. Bauman)

NASA's LSP customers and the future SLS program rely on observations of upper-level winds for steering, loads, and trajectory calculations for the launch vehicle's flight. On the day-of-launch, the 45 WS LWOs monitor the upper-level winds and provide forecasts to the launch team management via the AMU-developed Upper Winds tool. The 45 SW 915-MHz DRWPs and KSC 50-MHz

DRWP observations of wind speed and direction can be combined to create one continuous vertical wind profile of speed and direction. The 915-MHz DRWPs measure the winds at altitudes ranging from 285 to 14,560 ft (87–4,438 m) while the 50-MHz DRWP measures winds at altitudes ranging from 8,747 to 61,024 ft (2,700–18,600 m). Even though the nominal altitudes of the sensor's measurements overlap at the top of the 915-MHz DRWPs and bottom of the 50-MHz DRWP, the wind speeds and directions do not necessarily match at that interface. To compensate for this variation, MSFC NE developed algorithms to splice concurrent measurements from both profil-

ers. The AMU-developed LSP Upper Winds tool uses both DRWP sources to create a continuous profile of winds from approximately 427 to 61,024 ft (130–18,600 m). In the original LSP Upper Winds tool, the 915-MHz DRWP wind profile was cut off to match the bottom altitude of the 50-MHz DRWP wind profile or the wind profiles were connected via a straight line interpolation from the top of the 915-MHz data to the bottom of the 50-MHz data. The straight line interpolation was implemented due to time constraints levied on the task but it does not provide the smoothed profile that can be realized by splicing the data together among overlapping altitudes from both sensors.

LSP Upper Winds Tool Update

The final part of this work required porting the new VBA code into the existing LSP Upper Winds tool. There are 12 VBA modules in the tool that use data from both wind profilers. Each concurrent file from the 50-MHz DRWP and 915-MHz DRWP accessed by the LSP Upper Winds tool will need to be checked for missing data using the data gap filling algorithm, interpolated to 50-m altitude intervals using the interpolation algorithm, and then spliced together using the weighting scheme. Dr. Bauman copied the VBA code that was developed and tested independent of the LSP Upper Winds tool and inserted it in the appropriate modules in the tool. The code was modified to work within the framework of the existing code in the tool and then tested on archived data. An example of final spliced profiles of wind speed and wind direction from concurrent 915-MHz and 50-MHz DRWPs are shown in Figure 1.

During this task, the KSC 50-MHz DRWP was undergoing a complete replacement. Therefore, it was not possible to test the LSP Upper Winds tool with real-time data from the profiler. Once the replacement project is completed in late 2014, Dr. Bauman will test the LSP Upper Winds tool with the real-time data to ensure the newly developed code is working correctly before releasing the tool for operational support.

Final Report

Dr. Bauman completed writing the final report. It was reviewed internally by the AMU and externally by customers before distribution. It was approved by NASA Export Control and posted on the AMU website.

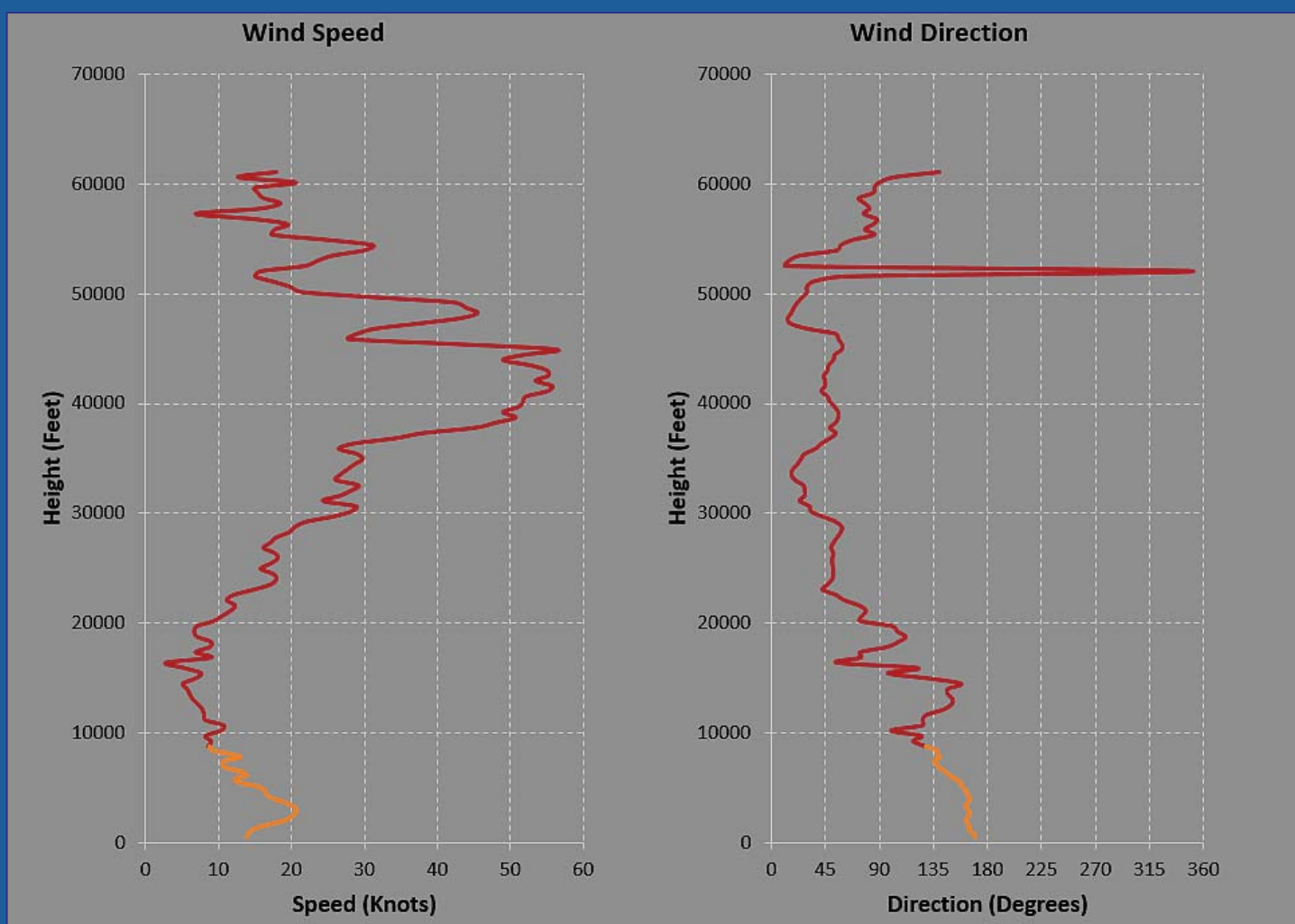For more information contact Dr. Bauman at 321-853-8202 or bauman.bill@ensco.com.

Figure 1. Spliced wind speed (left) and wind direction (right) from concurrent 915-MHz (orange line) and 50-MHz (red line) DRWPs as displayed in the LSP Upper Winds tool.

Range-Specific High-Resolution Mesoscale Model Setup: Data Assimilation (Dr. Watson)

The ER and WFF require high-resolution numerical weather prediction model output to provide more accurate and timely forecasts of unique weather phenomena that can affect NASA's LSP, GSDO, and future SLS daily operations and space launch activities. Global and national scale models cannot properly resolve important mesoscale features due to their horizontal resolutions being much too coarse. A properly tuned high-resolution model running operationally will provide multiple benefits to the launch community. This is a continuation of a previously customer-approved task that began in FY12 in which the WRF model was tuned for the ER and WFF (Watson 2013). This task recommends a local data assimilation and numerical forecast model design optimized for the ER and WFF to support space launch activities. The model will be optimized for local weather challenges at both ranges.

Validation of WRF Forecasts

Dr. Watson finished validating the GSI/WRF forecasts against the local observations using the MET verification package. She used two of the statistical verification tools available in MET, the Point-Stat tool and the Method For Object-Based Diagnostic Evaluation (MODE) tool. Point-Stat computes traditional verification scores by comparing the gridded GSI/WRF forecast to the corresponding local point observations. Dr. Watson computed hourly statistics for mean error (ME), root mean squared error (RMSE), and Pearson correlation coefficient (PCC) with this tool. The MODE tool applies an object-based verification technique in comparing a gridded forecast to a gridded analysis. The GSI/WRF accumulated precipitation forecasts were compared to the National Centers for Environmental Prediction's Stage IV precipitation data.

Results indicate that for both the ER and WFF, a triple-nest configuration that had a 9-km outer, 3-km middle, and 1-km inner nest was the optimal model configuration for both ranges. Figure 2 shows a sample of the average hourly ME, RMSE, PCC for wind speed for the 12-hour forecast over the entire period of record 27 August—10 November 2013 for the ER. However, although the results for the ER indicate that the triple-nest configuration performed best for most variables as evidenced by the ME, RMSE, and PCC, a double-nest configuration (2-km outer and 0.67-km inner nest) performed the best in predicting precipitation for the ER. Summertime convection over the ER is an important meteorological variable to predict and, for this reason, the AMU recommends using either the double-nest or triple-nest configuration as the optimal model configuration for the ER.
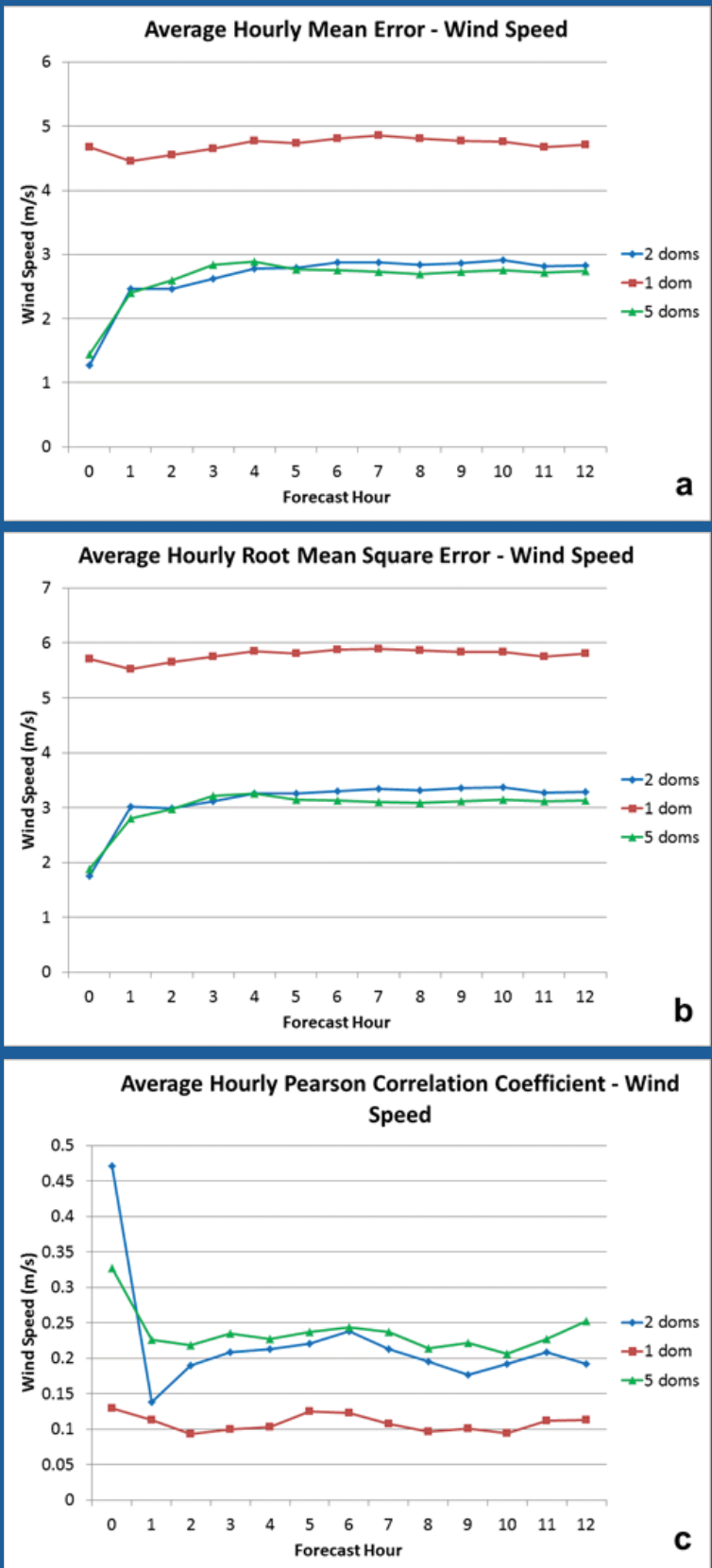

Figure 2. Charts of average hourly a) ME, b) RMSE, and c) PCC for the 12-hour wind speed forecast over the entire period of record from the three GSI/WRF configurations at the ER. In the legends, '2 doms' is the double-nest configuration (2-km outer, 0.67-km inner nest), '1 dom' is the single-domain configuration (1-km domain), and '5 doms' is the triple-nest configuration (9-km outer, 3-km middle, 1-km inner nest).

The triple-nest configuration performed the best for nearly all variables at WFF. Wind, temperature, and convective activity forecasts during the fall and spring seasons pose the most difficulties for forecasters at WFF. Therefore, the AMU recommends the triple-nested domain as the optimal configuration for WFF.

Final Report

Dr. Watson completed writing the final report. It has undergone internal review and is currently undergoing customer review. When that is complete, she will submit a request for NASA Export Control approval before distributing the report or posting it on the AMU website.

For more information contact Dr. Watson at watson.leela@ensco.com or 321-853-8264.

Real-time KSC/CCAFS High Resolution Model Implementation and Verification (Ms. Shafer and Dr. Watson)

NASA's LSP, GSDO, SLS and other programs at KSC and CCAFS use the daily and weekly weather forecasts issued by the 45 WS as decision tools for their day-to-day and launch operations on the ER. For example, to determine if they need to limit activities such as vehicle transport to the launch pad, protect people, structures or exposed launch vehicles given a threat of severe weather, or reschedule other critical operations. The 45 WS uses numerical weather prediction models, such as the Air Force Weather Agency (AFWA) 1.67 km WRF model, as a guide for their daily and weekly weather forecasts. Considering the 45 WS forecasters' and LWOs' extensive use of the AFWA model, the 45 WS proposed a task at the September 2013 AMU Tasking Meeting requesting the AMU verify this model. Due to the lack of archived model data available from AFWA, verification is not yet possible. The AMU then proposed to implement and verify the performance of an ER version of the AMU high-resolution WRF-EMS model (Watson 2013) in real-time. The tasking group agreed to this proposal and therefore the AMU implemented the WRF-EMS model on the second of two AMU modeling clusters. The AMU then made the model output available on the AMU AWIPS II servers, which allows the 45 WS and AMU staff to customize the model output display on the AMU and Range Weather Operations (RWO) AWIPS client computers and conduct real-time subjective analyses. The AMU will also calculate verification statistics to determine model performance compared to observational data. Implementing a real-time version of WRF-EMS will generate a larger database of model output than in the previous task for determining model performance, and will allow the AMU more control over and access to the model output archive.

Preliminary Verification Statistics

Ms. Shafer calculated preliminary model verification statistics to determine the 1.33-km domain WRF-EMS model performance for May and June 2014. The verification statistics were calculated using the MET software. Ms. Shafer used two of the statistical verification tools available, the Point-Stat and MODE tools (AMU Quarterly Report Q2 FY14).

Point-Stat was used to compute the ME and RMSE of the 2-m temperature and dewpoint (K), surface pressure (mb), and 10-m wind speed (m/s). The ME is the overall bias of the model parameter during the period of interest. It ranges from negative infinity to infinity with a perfect score equal to 0. The RMSE is the magnitude of the model error. Smaller RMSE values indicate better model performance. It ranges from 0 to infinity with a perfect score equal to 0.

Figure 3 shows the ME for each parameter versus model forecast lead time for May and June 2014. Figure 4 shows the same but for the RMSE. These charts illustrate, regardless of parameter and forecast lead time, the values are close to 0, which indicates good model performance.
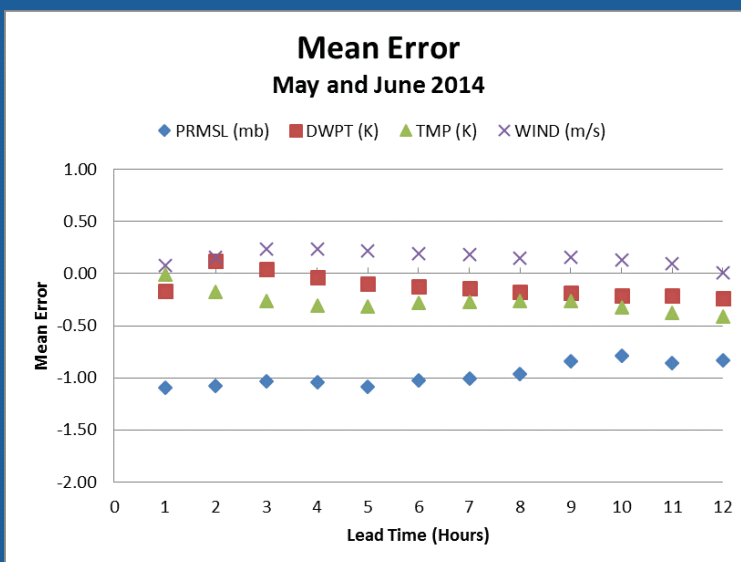

Figure 3. The ME for each parameter versus model forecast lead time. Surface pressure is in mb (blue diamonds), dewpoint in K (red squares), temperature in K (green triangles) and wind speed in m/s (purple Xs).

Ms. Shafer also used MODE to verify the model precipitation forecasts. MODE applies an object-based verification technique to compare a gridded forecast to a gridded analysis. The technique for defining objects in MODE is illustrated in Figure 5. Figure 5a is an example of raw gridded data. MODE uses two processes to convert raw gridded precipitation values into precipitation objects. The first step is to smooth the data (Figure 5b) and the second is to apply a threshold (Figure 5c). After these steps, MODE has defined precipitation objects (Figure 5d) to be used in the verification (Brown et al.
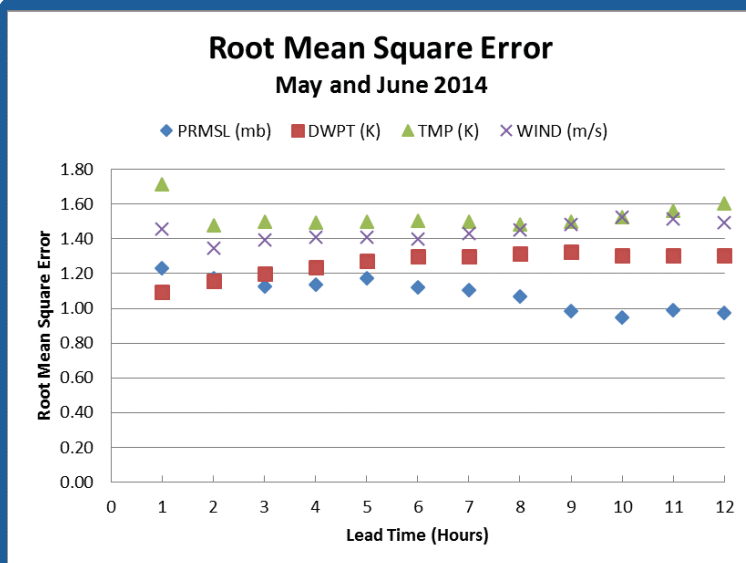
Root Mean Square Error
May and June 2014

Figure 4. Same as Figure 1 but for RMSE.

2007). Table 1 shows the statistics Ms. Shafer used from MODE for the model verification.

The centroid distance is the distance between the centers of two objects: the observed precipitation object and the corresponding forecast precipitation object. A perfect forecast would have a centroid distance equal to 0. Figure 6 shows the centroid distance versus model forecast lead time for the preliminary verification. As expected, there is a general increase in distance with time although it remains between 35 and 39 grid boxes. The distance in km is the centroid distance in grid boxes multiplied by the domain resolution of 1.33 km, resulting in distances between 46.55 and 51.87 km. Note that MODE does not calculate statistics for the initialization time (00L) since the model takes time to spin-up the precipitation forecasts.
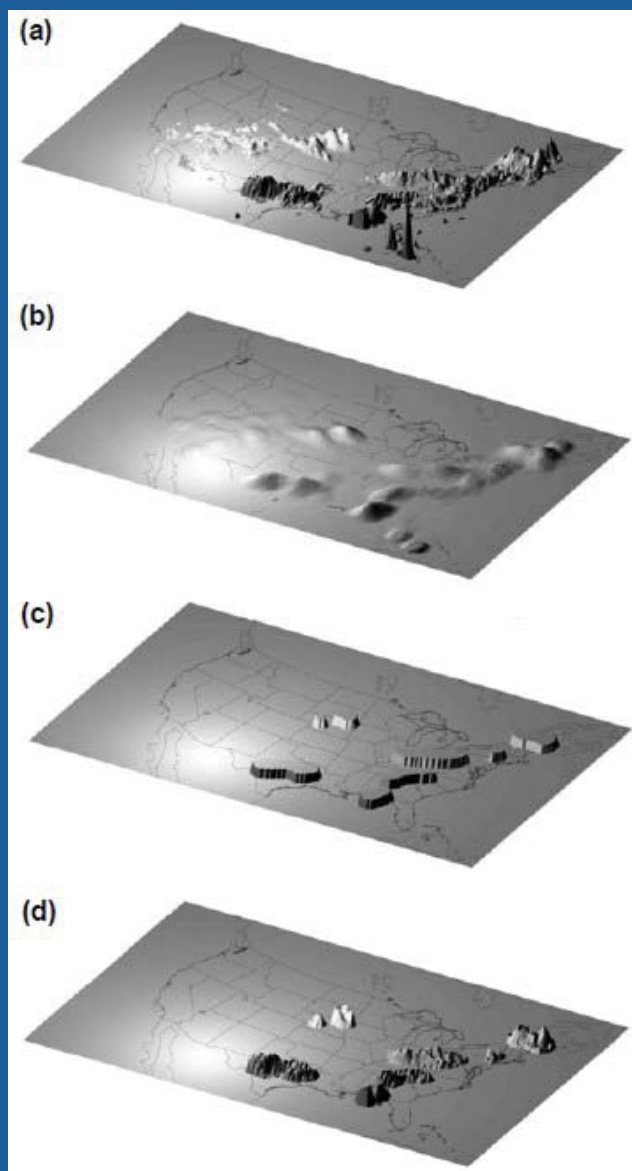

Figure 5. Illustration of the technique used in the MODE Tool to define precipitation objects: a) raw gridded precipitation data, b) smoothed data, c) result from application of thresholds, d) final field of objects used in verification statistics (Figure 2 in Brown et al. 2007).

Table 1. List of statistics available in the MODE tool Ms. Shafer used to verify the model.	
Statistic Name	**Description**
Centroid Distance	Distance between two objects centroids (in grid units)
Area Ratio	Ratio of the areas of two objects defined as the lesser of the forecast area divided by the observation area or its reciprocal (unitless)
Interest	Total interest value computed for a pair of simple objects (unitless)

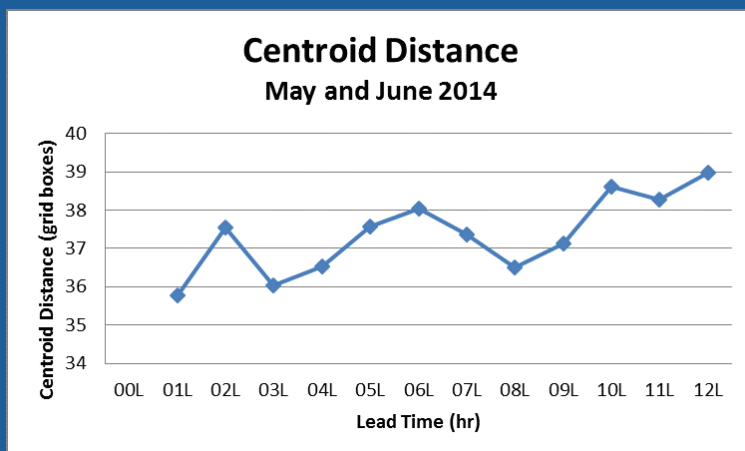**Centroid Distance**
May and June 2014

Figure 6. Centroid distance versus model forecast lead time for the preliminary model verification. Centroid distances are in number of grid boxes.

The area ratio compares the size of the forecast objects to the observation objects (forecast area/observation area). A perfect forecast would have an area ratio equal to 1. Figure 7 shows the area ratio versus model forecast lead time. The area ratio remains about 0.3. This means the model is consistently underforecasting the size of the precipitation objects.

Finally, the interest value compares the differences in attributes between the forecast and observed objects, including the centroid distance and area ratio, and gives an indication of the overall quality of the model precipitation forecasts. It ranges from 0 to 1 with a perfect score equal to 1. Figure 8 shows the interest versus model forecast lead time. This value consistently remains around 0.6 regardless of lead time. As the warm season progresses and more model forecasts are generated and added to the archive, these statistics will provide a more accurate indication of model performance.

Status

On 30 July, Ms. Shafer gave a presentation to members of the 45 WS, KSC Weather Office, LSP and Range Safety where she discussed how the WRF model is set up and that it is running in a rapid-refresh mode every hour, went over the preliminary verification statistics, and then explained how to access the model output in AWIPS.

Ms. Shafer will continue to generate verification statistics for the 1.33-km WRF domain as model forecasts become available. She will evaluate the entire warm season from May to September 2014 and document the results in the final report. The report will be available on the AMU website when NASA approval is received.

Contact Ms. Shafer at 321-853-8200 or shafer.jaclyn@ensco.com for more information.
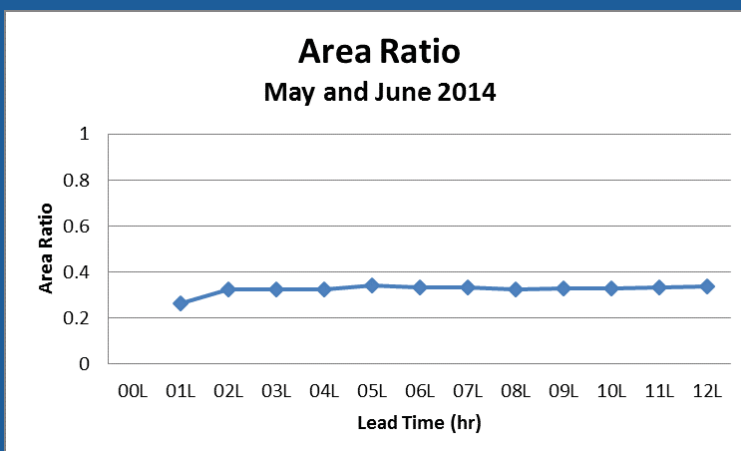

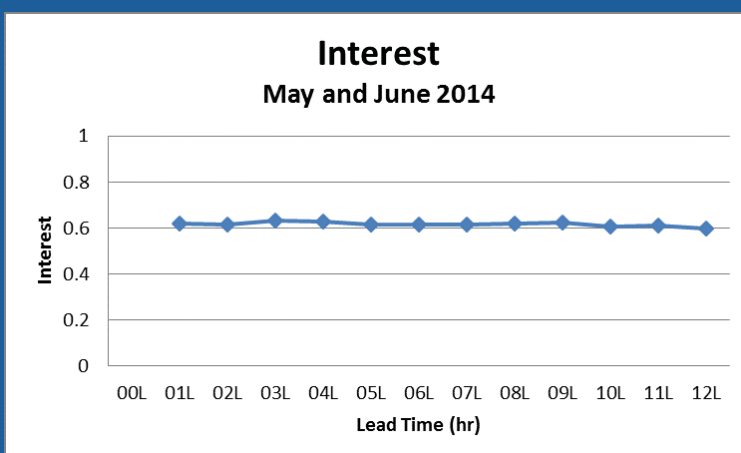*Figure 7. Area ratio versus model forecast lead time for the preliminary model verification.*

Figure 8. Interest versus model forecast lead time for the preliminary model verification.

Range-Specific High-Resolution Mesoscale Model Setup: Optimization (Dr. Watson)

The ER and WFF require high-resolution numerical weather prediction model output to provide more accurate and timely forecasts of unique weather phenomena that can affect NASA's SLS, LSP, and GSDO daily operations and space launch activities. Global and national scale models cannot properly resolve important mesoscale features due to their horizontal resolutions being much too coarse. A properly tuned high-resolution model running operationally will provide multiple benefits to the launch community. This is a continuation of a previously customer

-approved task that began in 2012 in which the AMU tuned the WRF model for the ER and WFF by determining the best model configuration and physics for the ER and WFF. The task continued in 2013 to provide a recommended local data assimilation (DA) and numerical forecast model design, which is a cycled DA and modeling system using the GSI and WRF software with scripts provided by NASA's Short-term Prediction Research and Transition Center (SPoRT). In this part of the task, the AMU will port GSI/WRF code to the AMU real-time cluster to run every three hours and display real-time output of the GSI/WRF cycled runs on the AMU's AWIPS workstations. The AMU will work with NASA SPoRT to determine if the GSI/WRF can be run

in a rapid-refresh mode. If so, the AMU will determine the time needed to set up the rapid-refresh system and will implement it if possible within the time frame of this task. In addition, the AMU will explore ensemble modeling using the WRF model and will determine the level of effort to set up an ensemble modeling system.

Real-time GSI/WRF Scripts

Dr. Watson began preparing the GSI/WRF scripts to run in real time. She is altering the scripts so the DA will run on the outer and nested domains, instead of just the outermost domain for both the ER and WFF.

For more information contact Dr. Watson at watson.leela@ensco.com or 321-853-8264.

AMU OPERATIONS

Meetings and Presentations

On 16 July, Ms. Shafer and Dr. Bauman attended a briefing presented by the Jet Propulsion Laboratory (JPL) about the effects of atmospheric turbulence on radio propagation and how this could affect the Ka-Band Objects Observation and Monitoring (KaBOOM) project. After the briefing, Dr. Watson discussed the AMU-WRF model and how it could help forecast atmospheric turbulence for JPL and KaBOOM operations.

On 17 July, Ms. Crawford, Ms. Shafer, and Dr. Bauman attended a briefing on the new National Hurricane Center wind speed probability product interpretation tool developed at the Florida Institute of Technology.

The AMU Staff participated in the AMU Tasking Meeting on 25 July with customers from GSDO, LSP, KSC Weather Office, 45 WS, MSFC, Johnson Space Center, and NWS MLB. The AMU customers assigned four new tasks to the AMU:

- Range-specific High-Resolution Mesoscale Model Setup: Tuning for Optimal Operational Performance
- Implement a local Weather Event Simulator for AWIPS
- Configuration and Evaluation of Dual-Doppler 3-D Wind Field System Phase II
- Evaluate Prediction of Local Sea Breeze Fronts from the 1.33-km Local Model

The AMU staff finished writing the draft task plans for each task of the four tasks assigned during the last tasking meeting and Dr. Bauman emailed them to Dr. Huddleston for distribution and review by the AMU customers before being inserted to the formal task plans.

On 30 July, Ms. Shafer gave a presentation to members of the 45 WS, KSC Weather Office, LSP and Range Safety titled "Real-time KSC/CCAFS High-resolution Model Implementation and Preliminary Verification". She discussed how the WRF model is set up and that it is running in a rapid-refresh cycle every hour, went over some preliminary verification statistics for the 1.33-km model domain, and then explained how to access the output in AWIPS.

Dr. Bauman, a co-author on a paper titled "Research Requirements to Improve Space Launch from Cape Canaveral Air Force Station and NASA Kennedy Space Center", completed a NASA Export Control approval request for the paper, which is being submitted by the 45 WS to the 1st Annual Space Traffic Management Conference hosted by Embry-Riddle Aeronautical University (ERAU). The co-authors are Mr. Roeder and Lt Col Doser from the 45 WS and Dr. Huddleston from the KSC Weather Office. The conference is scheduled for 5–6 November at ERAU in Daytona Beach.

On 11 September, the AMU staff participated in the Natural Environments Day-of-Launch Working Group (DOLWG) at WFF via telecon. They presented an overview of the AMU including AMU history, mission, tasking process, and examples of technical work that have been transitioned to operations at the ER, Western Range, WFF, and Edwards Air Force Base.

Dr. Bauman and Ms. Shafer attended a space weather briefing about the future of space weather detection and the capabilities of next generation satellites presented by the USAF Space and Missile Center.

Launch Support

Ms. Shafer attended the Launch Readiness Review (LRR) for the Falcon 9 launch scheduled for 14 July. During the meeting, the 45 WS discussed the different numerical weather prediction models they use for operations and mentioned the new AMU-WRF 1.33-km model available on AWIPS. The LWO's stated that the AMU-WRF model has been qualitatively accurate with its forecasts and would like to expand its use.

They also stated that 45 SW Range Safety is interested in the AMU-WRF model statistics as they consider switching the model they use for toxic dispersion analysis.

Dr. Bauman attended the 45 WS Delta 4 LRR on 21 July. During this meeting, the 45 WS Delta LWO, Ms. Winters, said she would be using the AMU-WRF model output model for her launch forecasts since she had been monitoring it since its deployment and noted that it was performing well. Ms. Winters said that the 45 SW Commander, Brig Gen Armagno, and her staff took special interest in its function and use.

On 23 July, the 45 WS LWO supporting the Delta 4 launch attempt asked Ms. Shafer to display the AMU-WRF model 1.33-km surface frontogenesis and simulated radar products as a reference for him to use as forecast guidance.

During the 26 July Delta 4 launch count, the LWO had to restart AWIPS in the RWO because the AMU-WRF model output was not updating. Once restarted, the model simulated reflectivity was displaying the storm cells in a uniform gray. The launch team asked Ms. Crawford to bring back the multi-color display. After making several attempts, she called Ms. Shafer for assistance. Ms. Shafer talked Ms. Crawford through the necessary steps to display the simulated reflectivities using a radar color table and was successful in getting the model-simulated reflectivity color display back on the RWO AWIPS.

During the Atlas 5 launch on 5 August, the LWO noted that the AMU-developed LSP Upper Winds tool did not display the CCAFS rawinsonde data. Dr. Bauman determined the data file was not available on the KSC Weather Archive server, which is where the tool gets the data. The file was available one hour later when the KSC Weather Archive site pulled the data from the Meteorological Interactive Data Display System (MIDDS). Once the file was available

in the KSC Weather Archive the tool functioned as designed.

Also during the Atlas 5 launch operation on 5 August, the primary forecast issue was whether or not a potentially electrified anvil cloud would dissipate in time for the launch to proceed. Dr. Bauman determined the AMU-WRF model could display model-simulated anvil cloud. He developed a procedure in the NASA/AMU AWIPS using the 4-km resolution AMU-WRF model showing the percent of cloud cover at the altitude of the anvil clouds. He displayed the new procedure on the 45 WS AWIPS and briefed the launch team on the product. The model was forecasting the anvil clouds to dissipate during the launch count, which they did before launch time.

Prior to the Falcon 9 launch attempt on 26 August, Dr. Bauman tested the LSP Upper Winds tool and discovered an error preventing it from running. Each time it made a data request, a window requesting username and password was displayed showing the request coming from the KSC Weather Archive site. Dr. Bauman notified Mr. Gemmer of Abacus Technology who maintains the KSC Weather Archive. Mr. Gemmer worked with Mr. Lockshire, also of Abacus Technology, who determined the cause of the error. Mr. Lockshire provided Dr. Bauman with several lines of code to replace the code in tool. Dr. Bauman tested the tool with the modified code and delivered it to the 45 WS before the launch attempt.

During the Falcon 9 launch on 7 September, the launch team was concerned that the winds calculated by the Anvil Threat Corridor tool in MIDDS were not consistent with those observed in the CCAFS sounding. Ms. Shafer assisted the team in determining that the winds were unusually weak in the typical anvil cloud layer from 25,000 to 45,000 ft and that the tool was working properly even though a subjective assessment of the wind direction was different from the tool calculation.

Forecaster Support

On 30 June, Dr. Bauman notified Ms. Winters about a wind speed parameter error in the in the waterspout tool in MIDDS. Ms. Winters looked at the MIDDS code and determined she could add "knots" to the parameters list command that writes the wind data to the file used by the waterspout tool. She tested and implemented the change to the code on 7 July. Mr. Madison of CSR copied the changed file to the MIDDS workstations. Dr. Bauman tested the MIDDS tool output against the Excel version of the tool and found the results to be in agreement.

On 8 July, the 45 WS duty forecasters asked Dr. Bauman if they could use the AMU GR2Analyst weather radar display software due to ongoing USAF network communications outages and the unavailability of GR2Analyst in the RWO. Dr. Bauman provided them access to this software as well as the GRLevel3 weather radar software on the workstation in the AMU lab area. He also showed them how to display the radar data on the NASA/AMU AWIPS located in the RWO.

On 9 July during the 45 WS daily weather discussion, Mr. McAleenan, the Falcon 9 LWO, commented that the 1.33-km AMU-WRF model accurately depicted the position and movement of the thunderstorms over east-central Florida. He asked Ms. Shafer and Dr. Bauman about the difference between the AMU-WRF model and the version of WRF the 45 WS receives from AFWA. While there are too many differences to list here, three main differences are:

- The AMU-WRF model is run every hour, 24 hours/day, and AFWA runs WRF once per day at 8:00 PM EDT,
- Dr. Watson tuned the AMU-WRF for the local area while the AFWA WRF was not, and
- AFWA provides one product to the 45 WS showing forecast radar reflectivity with surface winds while the NASA/AMU AWIPS can display the same product plus

dozens of other useful customized products output by the AMU-WRF model.

Ms. Shafer and Dr. Bauman demonstrated some of the features of the AMU-WRF model via the capabilities in the NASA/AMU AWIPS to Mr. McAleenan, Ms. Winters, 45 WS Delta LWO, and Lt Col Doser, 45 WS Operations Officer.

On 15 July, 45 WS forecaster TSgt Hunter asked the AMU how the old 45 WS MIDDS calculated the precipitable water (PW) parameter from the CCAFS sounding. He noticed a discrepancy between the old and new MIDDS upgrade values. The AMU told him the old MIDDS calculated PW up to about 18,000 ft and the new MIDDS may be using the meteorological standard altitude of about 31,000 ft. This agreed with the PW values TSgt Hunter identified between the old and new MIDDS. TSgt Hunter verified with Mr. Madison of CSR that the new MIDDS does calculate PW up to 31,000 ft. This change may be an issue for the AMU-developed Severe Weather tool in MIDDS since it uses the CCAFS PW as a predictor and was developed using old MIDDS PW values.

During the 45 WS daily weather discussion on 16 July, the duty forecasters mentioned the 45 SW WSR was not working. Also, the USAF network was down not allowing data from the NWS MLB weather radar to be displayed in the 45 WS GR2Analyst weather radar display software. Ms. Shafer confirmed the AMU GR2Analyst software was receiving real-time NWS MLB weather radar data and told the 45 WS they could use the AMU's display. The 45 WS also asked Ms. Shafer to display and customize the NWS MLB radar data available in AWIPS. Ms. Winters asked if there was a way to create radar cross-sections in AWIPS. They discovered a tool called Four-dimensional Stormcell Investigator (FSI) could do this; however, in order for FSI to work AWIPS must access the radar data directly from an NWS radar, which is not available through the CCAFS network.

Dr. Bauman talked to Mr. Voss at WFF about AMU support to the meteorological and safety organizations at WFF. Mr. Voss had made inquiries about weather technology transition support but was not aware of the AMU. Dr. Bauman described the AMU function and told him that WFF was an AMU customer because it is a NASA launch site. He also recommended that Mr. Voss attend the DOLWG on 11 September at WFF to learn more about weather support to space launch operations, and suggested several tasks the AMU could undertake to support the needs Mr. Voss described. Dr. Bauman recommended that he talk to Dr. Huddleston in the KSC Weather Office for further assistance.

Ms. May, a software engineer from Computer Sciences Corp at WFF, called Dr. Bauman to discuss AMU support for WFF range safety and meteorology. She had been trying to determine a way to provide more accurate wind observations and forecasts to support range safety as well as upper-level wind support for weather operations. She listened to the AMU overview briefing at the DOLWG and thought the AMU had capabilities to provide high resolution wind forecasts with high performance computer modeling. Dr. Bauman explained the AMU working relationship with customers including WFF, and how the AMU tasking process works. He also told her the AMU could support WFF with customer buy-in and KSC Weather Office approval. He referred Ms. May to Dr. Huddleston and Mr. Roeder to coordinate support with WFF, and 45th Range Safety who has similar interests in AMU modeling capability.

Reports and Publications

Ms. Shafer distributed an AMU memorandum documenting a comparison between the AMU-WRF model surface frontogenesis forecasts and corresponding radar observations from 1500 UTC on 17 June 2014. This memo was sent to members of the KSC Weather Office, 45 WS, WFF, and the 30th Operational Support Squadron Weather Flight.

IT

Ms. Shafer and Dr. Bauman contacted Ms. Keim in the KSC IT Security Office about updating the Continuous Monitoring items in the AMU IT Security Plan. Ms. Keim emailed the 2014 Continuous Monitoring checklist, which allowed them to start the process. They reviewed the Continuous Monitoring spreadsheet and provided the results to Ms. Keim. They also updated all supporting documents for the 2014 IT Security Plan. These documents included the AMU Contingency Plan, Hurricane Preparedness Plan, accreditation boundary diagrams, physical system diagrams, hardware list, software list, and IP address list.

Ms. Shafer and Dr. Bauman participated in NASA IT Security Risk Management System (RMS) to IT Security Test Center (ITSC) Transition Training on 3 September. NASA is migrating from RMS to ITSC for storage and maintenance of IT Security Plans.

Ms. Shafer and Dr. Bauman completed the IT Security vulnerability scanning of the AMU Linux systems on 22 September. The medium and high vulnerabilities were mitigated and the findings were reported to the KSC IT Security Office.

Ms. Shafer, Mr. Magnuson, and Dr. Bauman updated the NASA/AMU AWIPS software to the latest release on 11 and 12 August. This update improves overall software stability. This update should help mitigate some of the latency issues being experienced with the AMU-WRF model not updating in a timely manner.

The AFWA WRF output was supposed to be archived on the AMU modeling clusters beginning 1 May 2014, but issues related to transmitting the data have prevented it. On 7 August, Dr. Bauman, Ms. Shafer, and Mr. Magnuson participated in a telecon with KSC networking/firewall staff and AFWA IT administrators. The ENSCO, KSC, and AFWA personnel conducted numerous live tests during the telecon to try and determine why the AFWA servers

could not maintain a connection with the AMU modeling clusters. After more than two hours of testing, AFWA identified the return packets of data from the AMU modeling clusters were being denied at a gateway at Offutt Air Force Base controlled by the USAF 26th Network Operations Squadron (26 NOS). The 26 NOS needed to implement a rule to allow the two machines to communicate, which requires a mission requirements statement from the 45 WS. Maj Sweat, 45 WS Chief, Systems Division, emailed the requirements statement to AFWA on 8 August. The 26 NOS implemented the rule on 18 August. Mr. Magnuson tested the connection with Mr. Alger at AFWA and Dr. Bauman completed the setup on the AFWA website to initiate the automated push of files to the AMU clusters.

Security

Dr. Bauman reviewed an updated Visitor Group Security Agreement (VGSA) with the 45 SW Industrial Security (45 WS/IP) Officer and 45 WS Security Manager. He emailed the document to the ENSCO Corporate Director of Security and the ENSCO Aerospace Sciences and Engineering Division Security Manager for their signatures. The VGSA is required when a Department of Defense (DoD) organization provides Industrial Security Program support for a contractor operating on DoD property. The 45 WS Commander, Col Klug, signed the VGSA between ENSCO and the USAF on 20 August, completing all of the signatures except for the 45 SW/IP. Dr. Bauman scanned the signed document and emailed it to Mr. Chambers, 45 SW/IP Chief of Industrial Security on 21 August for his signature. The VGSA contains guidelines for the Air Force Industrial Security Program, which Ms. Crawford and Dr. Bauman manage for ENSCO/AMU.

The AMU has been using NASA-approved TrueCrypt encryption software to protect Sensitive but Unclassified (SBU) files on the AMU server since 2007. When attempting to upgrade the TrueCrypt to the latest ver-

sion, Dr. Bauman noticed a warning on the TrueCrypt website stating that it was no longer secure. Dr. Bauman notified Ms. Kniffin, a KSC IT specialist, and requested help identifying alternate encryption software to protect AMU SBU files. Ms. Keim and Mr. Manning of KSC GP-G determined TrueCrypt can no longer be used, but there is an accepted risk for strict logical access to the AMU directory structure on the AMU shared server using share and directory permissions. To invoke the accepted risk, Mr. Manning worked with Dr. Bauman and Dr. Huddleston to verify who should have access to the AMU directory structure and made the appropriate changes. Dr. Bauman removed all SBU files from the TrueCrypt encryption and placed stored the files on the server containing share and directory permissions set up by Mr. Manning.

Data Access and Display

The National Oceanic and Atmospheric Administration (NOAA) will expand the bandwidth on the AWIPS Satellite Broadcast Network (SBN/NOAAPort) feed from 30 Mbps to above 60 Mbps and change the frequency of the broadcast signal on 1 October. To support the transition for the NASA/AMU AWIPS, an AMU NOAAPort Receive System (NRS) software upgrade was required to receive the new frequency. Mr. Magnuson upgraded the AMU NRS software on 26 September, which resulted in a signal strength degradation down to ~11.2 dB and loss of some data in AWIPS. On 29 and 30 September Dr. Bauman and Mr. Magnuson manually adjusted the NRS satellite dish located at CCAFS on the south lawn of the Morell Operations Center (MOC) for azimuth and elevation to maximize the signal strength to 14.2 dB, eliminating the data loss.

The 45 WS MIDDS upgrade completed final acceptance testing and the old computers were replaced on 26 September. Dr. Bauman noticed the AMU-developed tools had not been transitioned to the new system and the MIDDS menu was incorrect. He notified the 45 WS Flight Commander, who notified CSR. On 29 September during the 45 WS morning briefing, Dr. Bauman noted the AMU-developed tools in the operational MIDDS had not yet been updated because the forecasters were reporting incorrect values. CSR then updated the operational MIDDS and Dr. Bauman confirmed that all AMU tools and the menu system were working correctly. The AMU MIDDS has not been upgraded but CSR stated they will do it after all of the operational systems are fully functioning.

Visitors

On 30 July, scientists from the FAA and National Center for Atmospheric Research (NCAR) visited the 45 WS while working on a lightning project for the FAA in Orlando. Part of their visit included an impromptu briefing and tour of the AMU presented by Dr. Bauman, Ms. Shafer, and Ms. Crawford. The scientists were particularly interested in the AMU technology transition process and affiliation with operational customers. The visiting scientists included Mr. Randy Bass (FAA Aviation Weather Research Program), Dr. Matthias Steiner (NCAR Deputy Director Research Applications Laboratory, Hydrometeorological Applications Program), Dr. Wiebke Deierling (NCAR Associate Scientist Research Applications Laboratory, Hydrometeorological Applications Program), and Mr. Eric Nelson (NCAR Associate Scientist Research Applications Laboratory, Hydrometeorological Applications Program).

On 14 August, Dr. Bauman. Ms. Crawford, and Dr. Watson presented an AMU overview briefing to the KSC Reorganization Team working on the formation of the new Technology and Research Directorate. The team visited the 45 WS RWO and the AMU. In addition to members of the new Research and Technology directorate, other NASA personnel attending the tour included the KSC Chief Technologist and members of Advanced Planning, GSDO, and Finance.

Mr. Tim Wilfong and Mr. Eric Gonzalez from DeTect visited the AMU on 28 August. They are part of the team replacing the KSC 50-MHz DRWP and requested a tour of the AMU. Dr. Bauman gave them an overview of the AMU and 45 WS RWO and Dr. Watson explained how the AMU-WRF model was tuned for local use at KSC/CCAFS and how the model was implemented by the AMU for real-time use to support operations at KSC/CCAFS and WFF.

The new 45th Operations Group Commander, Col Falzarano, visited the AMU on 18 September with the 45 WS Commander, Col Klug. The AMU staff gave Col Falzarano a brief overview of the AMU and described the support they've provided to USAF, NASA, and commercial launches.

Equipment

Dr. Bauman contacted several printer repair companies for quotes to replace the belt on the HP 500 large format roll printer. ICBM, Inc. replaced the belt at a cost of $240. A comparable replacement printer would have cost at least $4,300. The AMU purchased the large format printer 10 years ago to print posters for presenting AMU work at national conferences and other venues.

Training

Dr. Bauman completed the SATERN training course "IT Security for System Administrators – Beginning Level (ITS-RB1-SA)" as part of three training courses required to obtain permanent Elevated Privileges to maintain IT Security on non-ACES AMU computers.

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LIST OF ACRONYMS

14 WS	14th Weather Squadron
26 NOS	26th Network Operations Squadron
30 SW	30th Space Wing
30 OSS	30th Operational Support Squadron
3-D	Three Dimensional
45 RMS	45th Range Management Squadron
45 OG	45th Operations Group
45 SW	45th Space Wing
45 SW/SE	45th Space Wing/Range Safety
45 WS	45th Weather Squadron
AFB	Air Force Base
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMU	Applied Meteorology Unit
AWIPS	Advanced Weather Information Processing System
CCAFS	Cape Canaveral Air Force Station
CI	Convection Initiation
CSR	Computer Sciences Raytheon
DA	Data Assimilation
DoD	Department of Defense
DRWP	Doppler Radar Wind Profiler
ER	Eastern Range
ERAU	Embry-Riddle Aeronautical University
ESRL	Earth System Research Laboratory
FAA	Federal Aviation Administration
FSI	Four-dimensional Stormcell Investigator
FSU	Florida State University
GSDO	Ground Systems Development and Operations program
GSI	Gridpoint Statistical Interpolation
ITSC	IT Security Test Center
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KaBOOM	Ka-Band Objects Observation and Monitoring

KSC	Kennedy Space Center
LRR	Launch Readiness Review
LSP	Launch Services Program
LWO	Launch Weather Officer
ME	Mean Error
MET	Model Evaluation Tools
MIDDS	Meteorological Interactive Data Display System
MODE	Method For Object-Based Diagnostic Evaluation
MSFC	Marshall Space Flight Center
NCAR	National Center for Atmospheric Research
NE	Natural Environments Branch at MSFC
NOAA	National Oceanic and Atmospheric Administration
NRS	NOAAPort Receive System
NSSL	National Severe Storms Laboratory
NWA	National Weather Association
NWS MLB	National Weather Service in Melbourne, Florida
PCC	Pearson Correlation Coefficient
PW	Precipitable Water
RMS	Risk Management System
RMSE	Root Mean Square Error
RWO	Range Weather Operations
SLS	Space Launch System
SMC	Space and Missile Center
SPoRT	Short-term Prediction Research and Transition Center
USAF	United States Air Force
VBA	Visual Basic for Applications in Excel
VGSA	Visitor Group Security Agreement
WFF	Wallops Flight Facility
WRF	Weather Research and Forecasting Model
WRF-EMS	WRF Environmental Modeling System
WSR	45 SW Weather Surveillance Radar

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NASA WFF/840.1/A. Thomas
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45 SW/CD/G. Kraver
45 SW/SELR/K. Womble
45 SW/XPR/R. Hillyer
45 OG/CC/D. Schiess
45 OG/TD/C. Terry
CSC/M. Maier
CSR 1000/S. Griffin
CSR 3410/C. Adams
CSR 3410/R. Crawford
CSR 3410/D. Pinter
CSR 3410/M Wilson

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NOAA "W/NP"/L. Uccellini
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NWS/OST/PPD/SPB/P. Roohr
NSSL/D. Forsyth
30 OSS/OSWS/DO/B. Lisko

30 OSS/OSWS/M. Schmeiser
30 OSS/OSWS/T. Brock
30 SW/XPE/R. Ruecker
Det 3 AFWA/WXL/K. Lehneis
NASIC/FCTT/G. Marx
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